

What is claimed is:

1 1. A projection optical system for enlarging and projecting an image of an image display element  
2 onto a screen comprising:

3 a first prism that includes an incident light refracting surface for receiving light from the  
4 image display element, said incident light refracting surface being the incident light refracting  
5 surface of the projection optical system;

6 a second prism that includes an exit light refracting surface for emitting light toward the  
7 screen, said exit light refracting surface being the exit light refracting surface of the projection  
8 optical system; and

9 prism internally reflecting surfaces having optical power arranged so that light that enters  
10 said incident light refracting surface from the image display element is reflected at least six  
11 times before exiting said exit light refracting surface;

12 wherein

13 the projection optical system does not form an intermediate image of the image display  
14 element between said incident light refracting surface and said exit light refracting surface; and

15 the projection optical system can operate with finitely separated conjugates without any  
16 additional converging optics.

1 2. The projection optical system of claim 1, including one or more additional prisms having  
2 internally reflecting surfaces.

1 3. The projection optical system of claim 2, including a diaphragm positioned between two  
2 prisms.

1 4. The projection optical system of claim 3, wherein said diaphragm operates as an ideal aperture  
2 stop only for finitely separated optical conjugates.

1 5. The projection optical system of claim 1, wherein at least one surface of the following  
2 surfaces of at least one prism is an aspheric surface: an incident light refracting surface, an  
3 internally reflecting surface, or an exit light refracting surface.

1 6. The projection optical system of claim 1, wherein at least one surface of the following  
2 surfaces of at least one prism is a free-form surface: an incident light refracting surface, an  
3 internally reflecting surface, or an exit light refracting surface.

1 7. The projection optical system of claim 1, wherein at least one surface of the following  
2 surfaces of at least one prism is a rotationally symmetric aspherical surface: an incident light  
3 refracting surface, an internally reflecting surface, or an exit light refracting surface.

1 8. The projection optical system of claim 4, wherein the finitely separated optical conjugates for  
2 which the diaphragm operates as an ideal aperture stop satisfy the following condition:

3 
$$L1 / L2 < 20$$

4 where

5 L1 is the conjugate distance of the projection optical system as measured on-axis on the  
6 enlarging side between said exit light refracting surface and said projected image, and

7 L2 is the conjugate distance of the projection optical system as measured on-axis on the  
8 reducing side between said image display element and said incident light refracting surface.

1 9. The projection optical system of claim 8, wherein L1 and L2 are of the same order of  
2 magnitude.

1 10. A projection-type image display apparatus, comprising:  
2 an image display apparatus;  
3 a screen; and

4           the projection optical system of claim 1 for projecting an enlarged image of said image  
5 display apparatus onto said screen.

1       11. A projection-type image display apparatus, comprising:

2           an image display apparatus;

3           a screen; and

4           the projection optical system of claim 2 for projecting an enlarged image of said image  
5 display apparatus onto said screen.

1       12. A projection-type image display apparatus, comprising:

2           an image display apparatus;

3           a screen; and

4           the projection optical system of claim 3 for projecting an enlarged image of said image  
5 display apparatus onto said screen.

1       13. A projection-type image display apparatus, comprising:

2           an image display apparatus;

3           a screen; and

4           the projection optical system of claim 4 for projecting an enlarged image of said image  
5 display apparatus onto said screen.

1       14. A projection-type image display apparatus, comprising:

2           an image display apparatus;

3           a screen; and

4           the projection optical system of claim 5 for projecting an enlarged image of said image  
5 display apparatus onto said screen.

1 15. A projection-type image display apparatus, comprising:

2 an image display apparatus;

3 a screen; and

4 the projection optical system of claim 6 for projecting an enlarged image of said image  
5 display apparatus onto said screen.

1 16. A projection-type image display apparatus, comprising:

2 an image display apparatus;

3 a screen; and

4 the projection optical system of claim 7 for projecting an enlarged image of said image  
5 display apparatus onto said screen.

1 17. A projection-type image display apparatus, comprising:

2 an image display apparatus;

3 a screen; and

4 the projection optical system of claim 1 for projecting an enlarged image of said image  
5 display apparatus onto said screen;

6 wherein the following condition is satisfied:

7 
$$L1 / L2 < 20$$

8 where

9 L1 is the conjugate distance as measured on-axis on the enlarging side between said exit  
10 light refracting surface of the projection optical system and said projected image, and

11 L2 is the conjugate distance as measured on-axis on the reducing side between said image  
12 display element and said incident light refracting surface of the projection optical system.

1 18. A projection-type image display apparatus, comprising:

2 an image display apparatus;

3 a screen; and  
4 the projection optical system of claim 3 for projecting an enlarged image of said image  
5 display apparatus onto said screen;  
6 wherein the following condition is satisfied:

$$L1 / L2 < 20$$

8 where

9 L1 is the conjugate distance as measured on-axis on the enlarging side between said exit  
10 light refracting surface of the projection optical system and said projected image, and

11 L2 is the conjugate distance as measured on-axis on the reducing side between said image  
12 display element and said incident light refracting surface of the projection optical system.

1 19. A projection-type image display apparatus, comprising:

2 an image display apparatus;

3 a screen; and

4 the projection optical system of claim 4 for projecting an enlarged image of said image  
5 display apparatus onto said screen;  
6 wherein the following condition is satisfied:

$$L1 / L2 < 20$$

8 where

9 L1 is the conjugate distance as measured on-axis on the enlarging side between said exit  
10 light refracting surface of the projection optical system and said projected image, and

11 L2 is the conjugate distance as measured on-axis on the reducing side between said image  
12 display element and said incident light refracting surface of the projection optical system.

1 20. The projection-type image display apparatus of claim 19, wherein L1 and L2 are of  
2 the same order of magnitude.